



High Level Architecture

SCS Summer Simulation Conference

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Outline

- **Motivations for HLA development**
- **The High Level Architecture (HLA)**
- **HLA Use Processes, User Support and Supporting Software**
- **HLA in related standards efforts: JTA, NATO, SISO/IEEE, OMG**



M&S Critical to US DoD's Ability to Meet its Mission

Continuing squeeze on DoD resources

- Shrinking, dispersed force structure
- Competition for O&M funds limits field exercises
- Need to carefully examine every investment

More demanding operational requirements

- New, more complex missions
- Vastly expanding mission space
- Increased complexity of systems and plans
- Increasing demand for joint training
- Security challenges (e.g., information warfare)
- No traditional way to address

Much more technical capability at less cost

- Communications
- Computers
- Advanced software technology
- Displays/human-machine interfaces
- Data storage and management

**Advanced
M&S
offers a cost-effective
and
affordable
solution**



Recent US DoD M&S History

Technical progress spurs management response

Technical

Limited scope simulations,
little interoperability prior to 1988

SIMNET

**DSB: Computer Applications
to Training and Wargaming Study for CJCS**

**DARPA-SACEUR
Distributed
Wargaming
System ACE-89**

**DIS Standards
begin:
linking of Service wargames**

**New programs
(JSIMS, JWARS)**

**High Level Architecture
(HLA) begun**

**HLA Baseline
Established 1.1
1.3 (IEEE)
HLA Spec Evo 1.2**

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**DoD Simulation
Policy Study**

**DoD SECDEF Memo
EXCIMS formed
and DMSO established**

**DoD Dir 5000.59
M&S Management**

**DoD 5000.59
M&S Master Plan**

**DoD M&S
Executive Agency**

**HLA
Policy established**

**SBA Task
Force**

**DoD V&A
Instruction**

**EXCIMS offer
a Vision for
DoD M&S**

**All Services
M&S offices
put in place**

**Architecture
Management Group**

**EXCIMS
Functional Area Councils**

**HLA Transi
Plan appro**

Management

No formal management structure / Management structure stand-up / Management structure in place



US DoD M&S Vision

Defense modeling and simulation will provide readily-available, operationally-valid environments for use by DoD components

- To train jointly, develop doctrine and tactics, formulate operational plans, and assess war fighting situations**
- As well as to support technology assessment, system upgrade, prototype and full scale development, and force structuring.**

Furthermore, common use of these environments will promote a closer interaction between the operations and acquisition communities in carrying out their respective responsibilities. To allow maximum utility and flexibility, these modeling and simulation environments will be

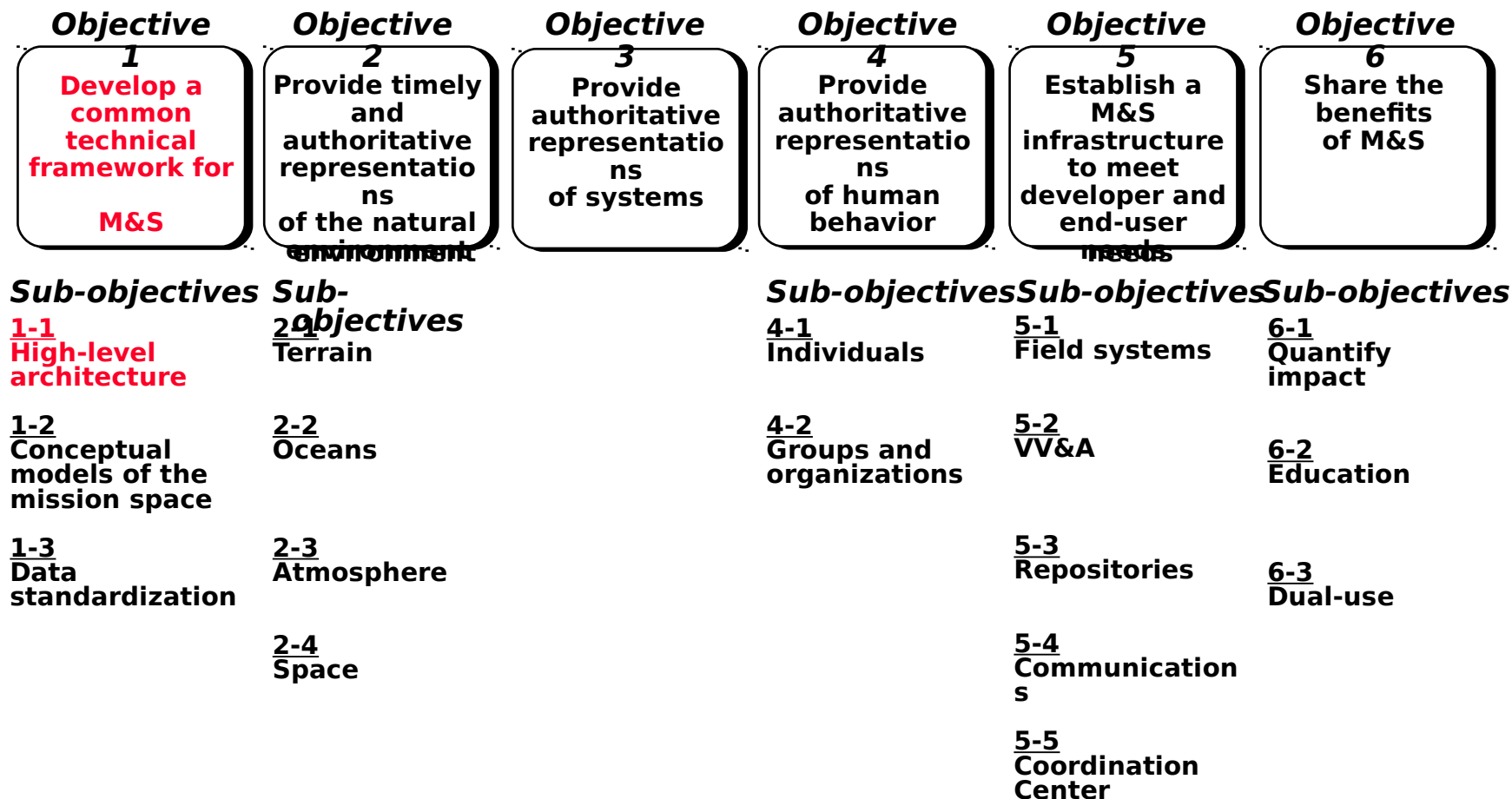
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DoD Executive Council on Modeling and Simulation (EXCIMS),

March 13, 1992



US Defense-wide M&S Master Plan



DoD 5000.59-P, Modeling and Simulation Master Plan, October 1999



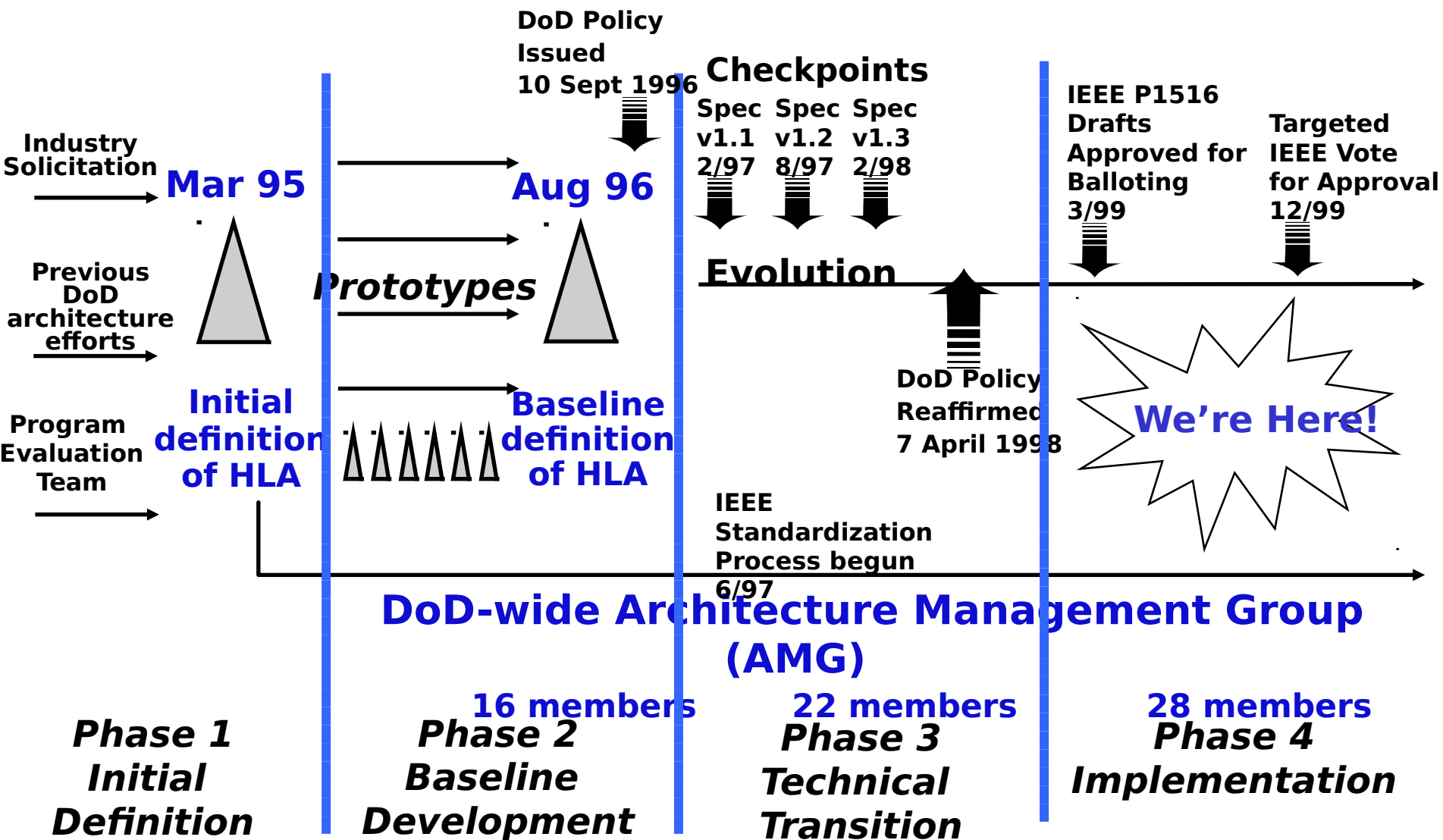
M&S Master Plan Objective 1-1

Objective 1-1

- **Establish a common high-level simulation architecture to facilitate the interoperability of all types of models and simulations among themselves and with C4I systems, as well as to facilitate the reuse of M&S components**
- **Simulations developed for particular DoD Components or Functional Areas must conform to the High Level Architecture**
 - **Further definition and detailed implementation of specific simulation system architectures remain the responsibility of the developing Component**



Review of the HLA Development Process





US Defense HLA Policy

DoD Policy:

“Under the authority of [DoD Directive 5000.59], and as prescribed by [the DoD Modeling and Simulation Master Plan], I designate the High Level Architecture as the standard technical architecture for all DoD simulations.”

- HLA supersedes Distributed Interactive Simulation (DIS) and ALSP
- **“No Can” Dates**
 - **“No Can Pay”**- first day of FY99
 - no funds for developing/modifying non-HLA-compliant simulations
 - **“No Can Play”**- first day of FY01
 - retirement of non-HLA-compliant simulations
- **Waivers must be decided on a corporate basis**



DoD HLA Policy Reaffirmation

DoD Transition Policy

“We must foster broad simulation interoperability and reuse if the Department is to cost-effectively harness the potential of simulation to improve DoD operations.”

“All new simulations will be built in accordance with the HLA.

To reap the full benefits of simulation interoperability and reuse

in the near-term, it is also important to quickly transition our legacy simulations to the HLA, ... I encourage our industry partners to follow suit”

**Dr. J.S. Gansler, USD(A&T)
7 April 1998**



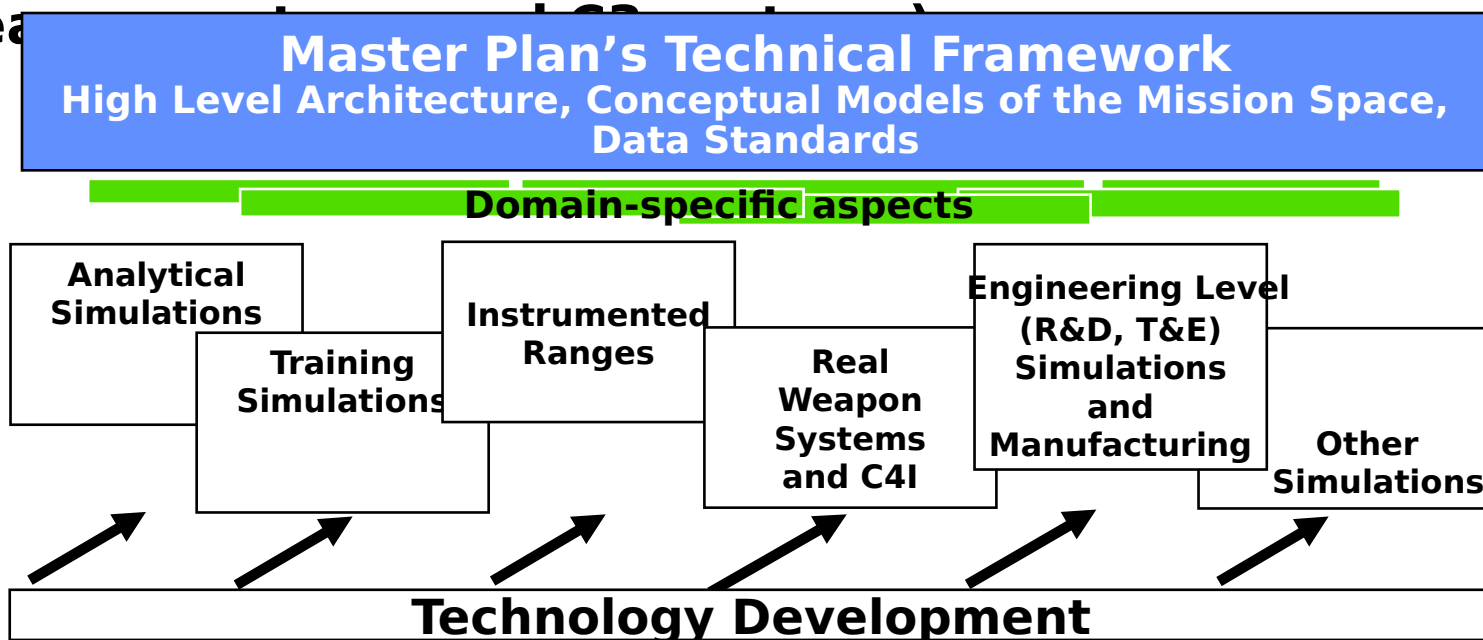
What is the High Level Architecture?

- The High Level Architecture is comprised of three elements:
 - An **Interface Specification** which describes the way compliant simulations interact during operation
 - An **Object Model Template (OMT) Specification** which specifies the form in which simulation elements are described
 - A set of **HLA Rules for Federates and Federations** which define relationships among federating compliant simulations
- These three elements, commonly applicable across all DoD simulations, provide a common framework within which specific system architectures can be defined
- HLA's composable approach promotes:
 - INTEROPERABILITY among simulations within a federation, and across functional M&S communities, and
 - REUSE of simulation components across federations, functional M&S communities, and runtime infrastructures.



What is the Scope of HLA?

- Applicable to broad range of functional areas (e.g., training, contingency planning, analysis, and acquisition)
- Applicable to simulations involving pure software representations, man-in-the-loop simulators, and interfaces to live components (e.g., instrumented-weapons)





What was the Rationale for HLA Design?

- **Basic premises:**

- No single, monolithic simulation can satisfy the needs of all users
- All uses of simulations and useful ways of combining them cannot be anticipated in advance
- Future technological capabilities and a variety of operating configurations must be accommodated

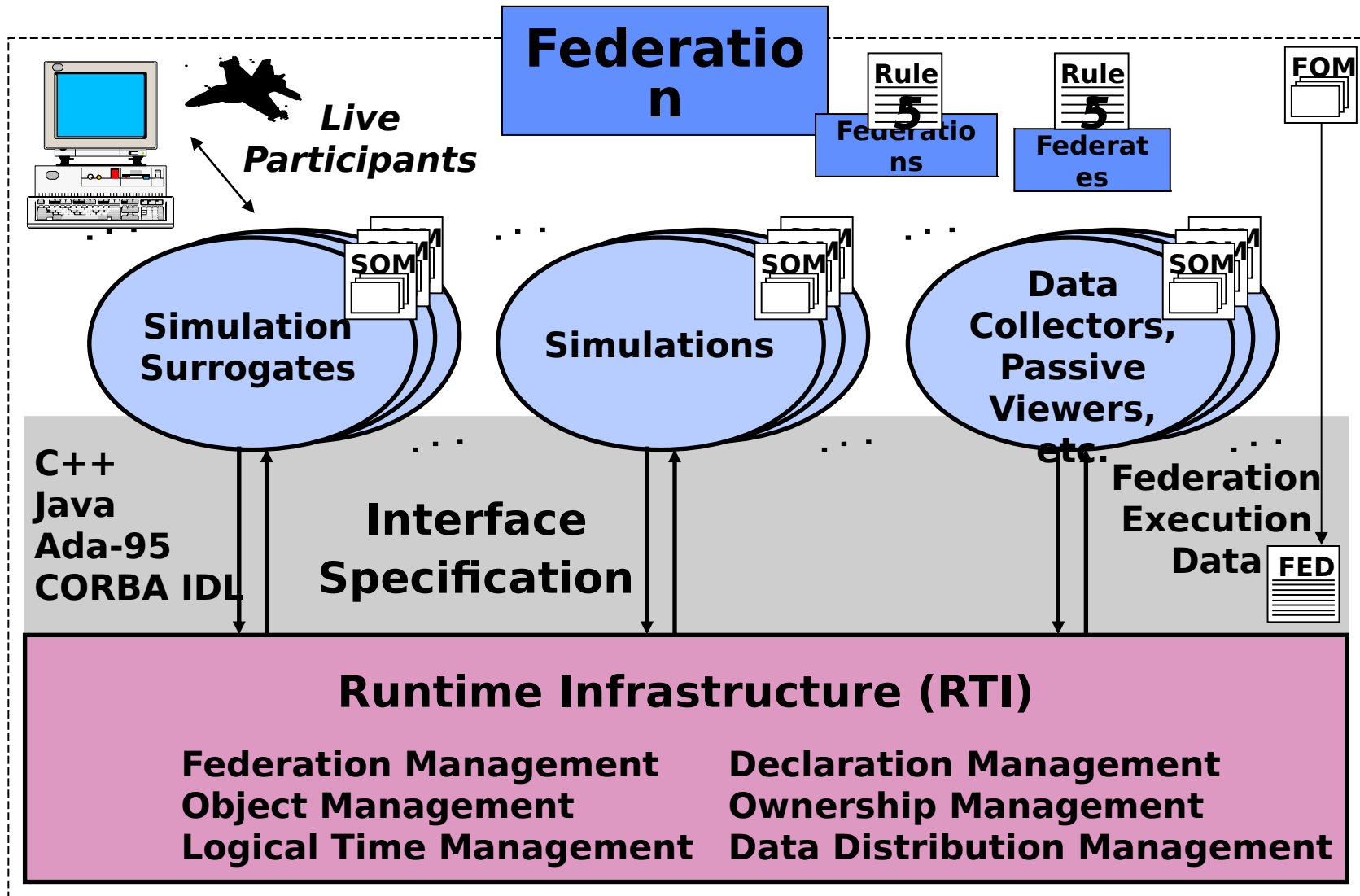
- **Consequence:** Need **composable** approach to constructing simulation federations

- **Resulting design principles:**

- Federations of simulations constructed from modular components with well-defined functionality and interfaces
- Specific simulation functionality separated from general purpose supporting runtime infrastructure



Functional View of the High Level Architecture





Some Terminology

- **Federation:** a set of simulations, a common federation object model, and supporting RTI, that are used together to form a larger model or simulation
- **Federate:** a member of a federation; one simulation
 - Could represent one platform, like a cockpit simulator
 - Could represent an aggregate, like an entire national simulation of air traffic flow
- **Federation Execution:** a session of a federation instance executing over time



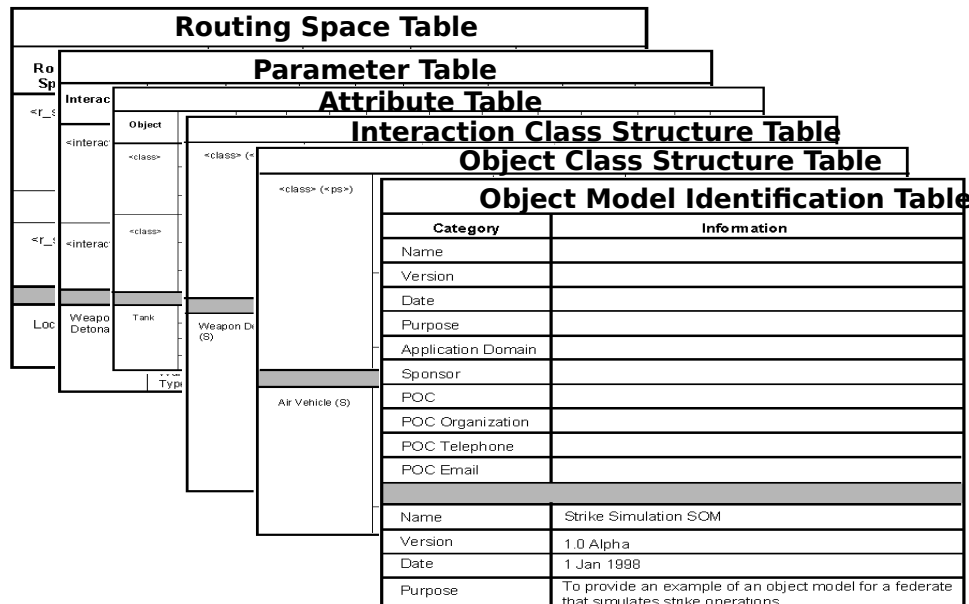
HLA Object Models and OMT

- **Federation Object Model (FOM)**

- A description of all shared information (objects, attributes, and interactions) essential to a particular federation

- **Simulation Object Model (SOM)**

- Describes objects, attributes and interactions in a particular simulation which *can* be used externally in a federation

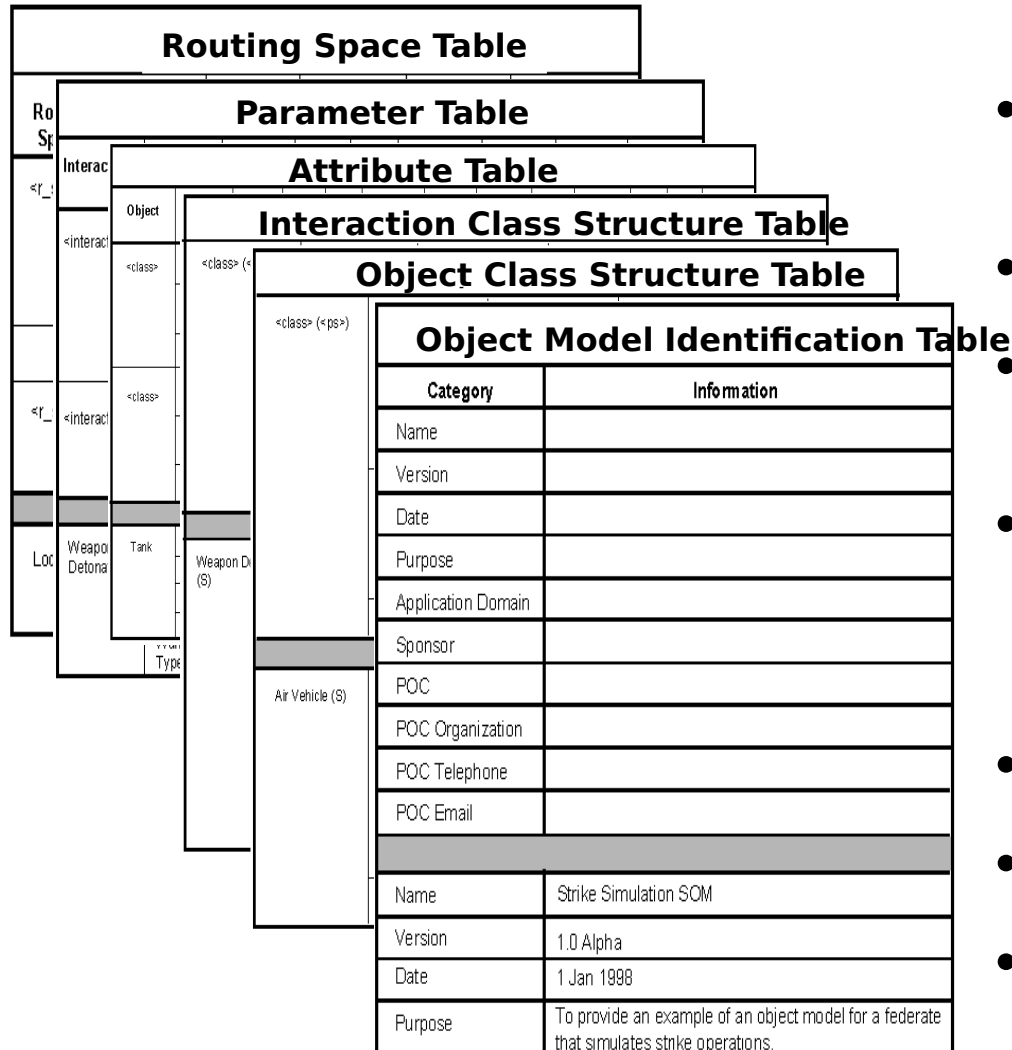


Object Model Template (OMT)

- Provides a common framework for HLA object model documentation
- Fosters interoperability and reuse of simulations via the specification of a common representational framework



Components of the Object Model Template



- Object Model Identification Table
- Object Class Structure Table
- Interaction Class Structure Table
- Attribute Table
 - Enumerated Datatype Table
 - Complex Datatype Table
- Parameter Table
- Routing Space Table
- FOM/SOM Lexicon



Interface Specification

- **Provides a specification of the functional interfaces between federates and the RTI**
 - Interfaces are divided into six service groups
- **Each service specification includes:**
 - Name and Descriptive Text
 - Supplied Arguments
 - Returned Arguments
 - Pre-conditions
 - Post-conditions
 - Exceptions
 - Related Services
- **Application Programmer Interfaces (APIs) in CORBA IDL, C++, Ada '95 and Java**

What Does the Interface Specification Include



Integrated Training Program

- **Six HLA Runtime Infrastructure Service Groups**
 - **Federation Management (20 services)**
 - **Declaration Management (12 services)**
 - **Object Management (17 services)**
 - **Ownership Management (16 services)**
 - **Time Management (23 services)**
 - **Data Distribution Management (13 services)**
- **The Interface Specification also includes:**
 - **Support Services (29 services)**
 - **Management Object Model**
 - **Federation Execution Data (FED)**
 - **Application Programmers Interfaces (APIs)**



HLA RTI Services Categories

Category	Functionality
Federation Management	Create and delete federation executions Join and resign federation executions Control checkpoint, synchronization
Declaration Management	Establish intent to publish and subscribe to object attributes and interactions
Object Management	Create and delete object instances Control attribute and interaction publication Create and delete object reflections
Ownership Management	Transfer ownership of object attributes
Time Management	Coordinate the advance of logical time and its relationship to real time
Data Distribution Mgmt	Supports efficient routing of data



Federation Rules

- 1. Federations shall have an HLA Federation Object Model (FOM), documented in accordance with the HLA Object Model Template (OMT).**
- 2. In a federation, all representation of objects in the FOM shall be in the federates, not in the runtime infrastructure (RTI).**
- 3. During a federation execution, all exchange of FOM data among federates shall occur via the RTI.**
- 4. During a federation execution, federates shall interact with the runtime infrastructure (RTI) in accordance with the HLA interface specification.**
- 5. During a federation execution, an attribute of an instance of an object shall be owned by only one federate at any given time.**



Federate Rules

- 6. Federates shall have an HLA Simulation Object Model (SOM), documented in accordance with the HLA Object Model Template (OMT).**
- 7. Federates shall be able to update and/or reflect any attributes of objects in their SOM and send and/or receive SOM object interactions externally, as specified in their SOM.**
- 8. Federates shall be able to transfer and/or accept ownership of attributes dynamically during a federation execution, as specified in their SOM.**
- 9. Federates shall be able to vary the conditions (e.g., thresholds) under which they provide updates of attributes of objects, as specified in their SOM.**
- 10. Federates shall be able to manage local time in a way which will allow them to coordinate data exchange with other members of a federation.**



HLA User Services

- **DMSO is fostering a broad range of Outreach Activities to facilitate transition to the HLA:**
 - **DMSO HLA Web Site / Home Page**
 - **HLA Support Processes**
 - **HLA Supporting Software and Tools**
 - **HLA User Services**
 - **Help Desk**
 - **HLA Education/Outreach**
 - **HLA Compliance Testing**
 - **HLA Standardization Initiatives**

HLA User Services: DMSO HLA Home Page



Integrated Training Program

- Provides full service access to the broad HLA user community

Materials, information, software distribution, training registration



- Please set your bookmarks to

<http://hla.dmsol.mil>

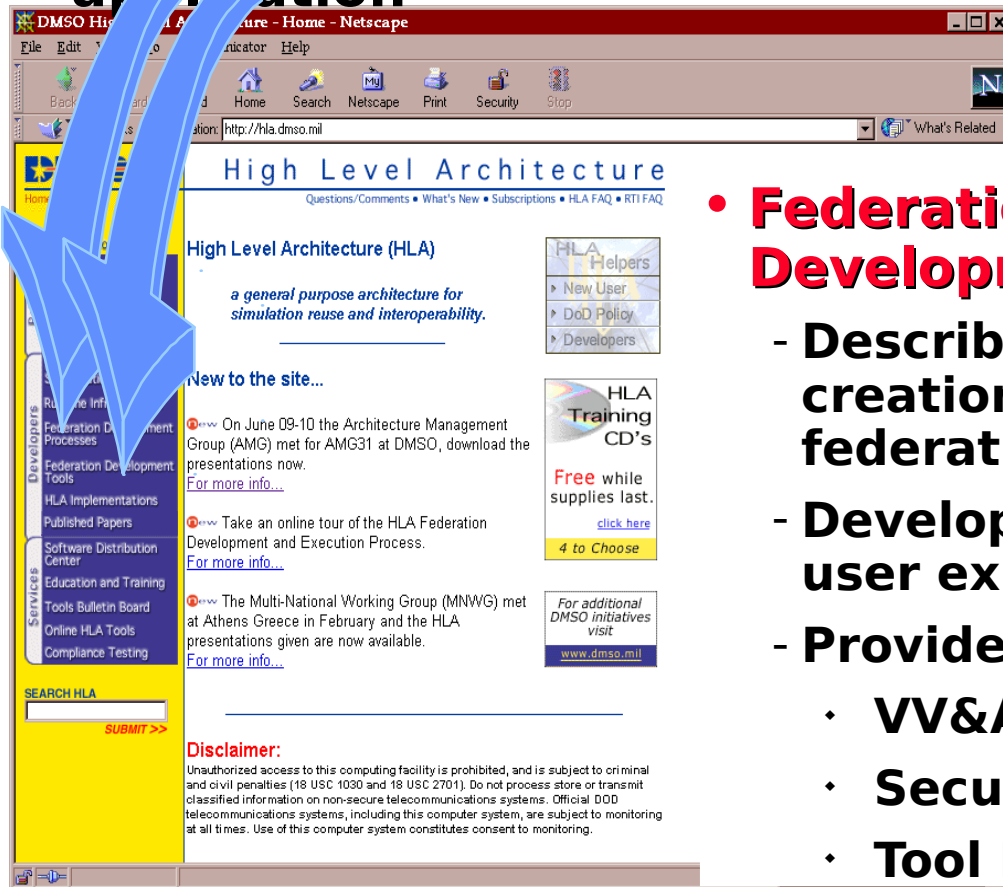
- This will provide direct access to the DMSO HLA Home Page
- Restructured DMSO HLA Home Page
 - General Information divided into Policy, Developers, and Services
 - Added “New to the site...”
 - Added HLA Training CD availability
 - Changed “look” of HLA Helpers

HLA User Services: HLA Support Processes



Integrated Training Program

- Formalized views of HLA use processes to support HLA application



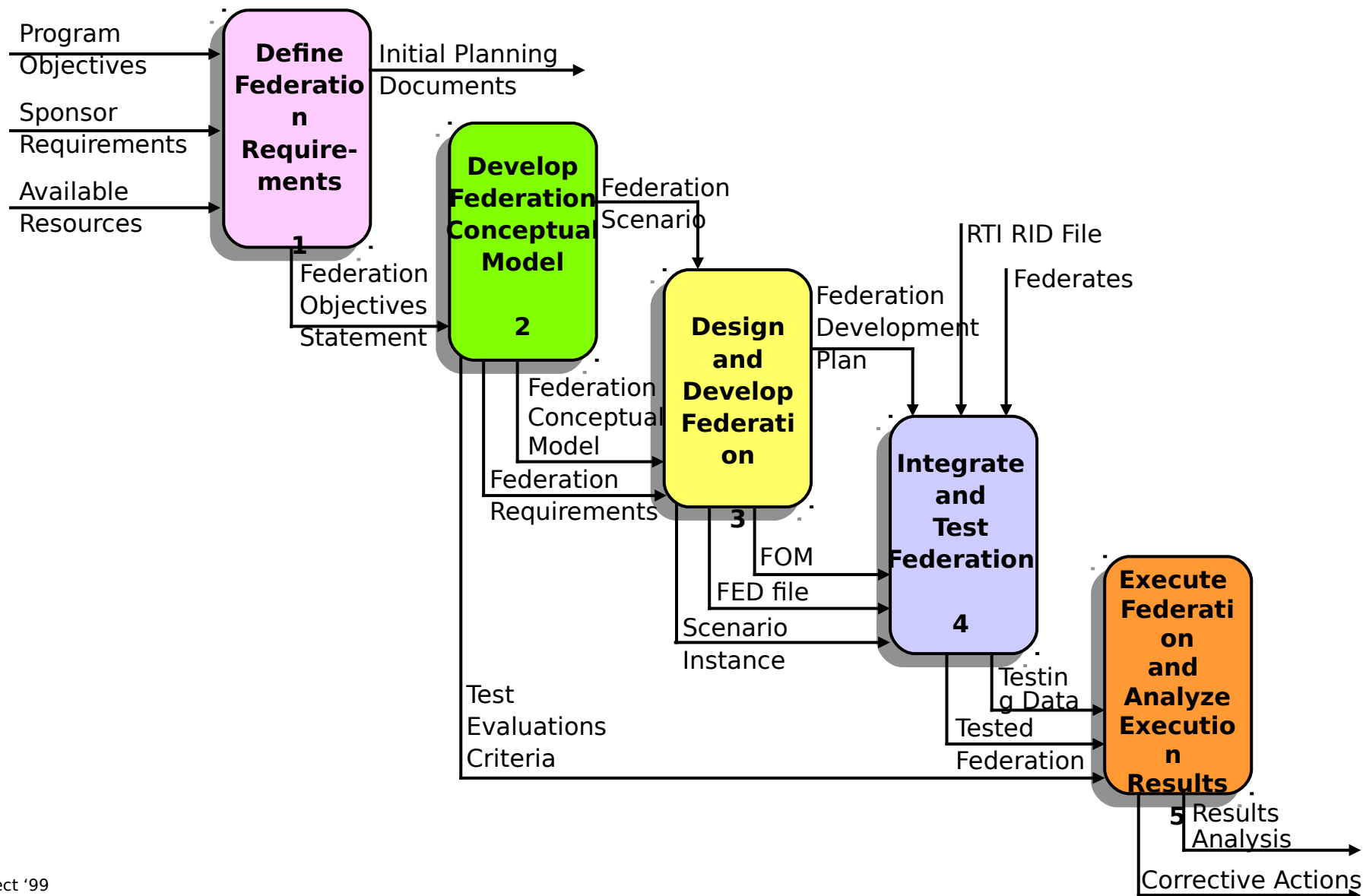
- **Federation Execution & Development Process (FEDEP)**

- Describes major stages in the creation and use of an HLA federation
- Developed and evolved based on user experience
- Provides framework for
 - VV&A processes
 - Security
 - Tool Development



HLA FEDEP Model

High Level View



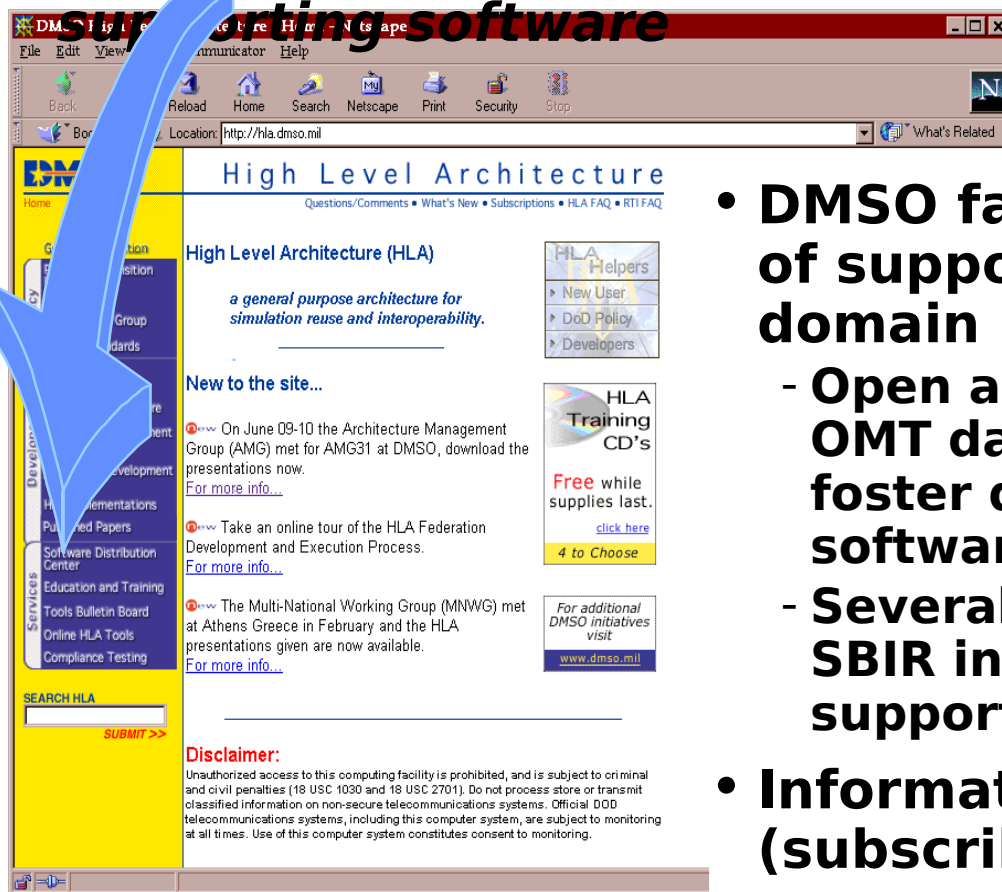
HLA Supporting Software: Philosophy



Integrated Training Program

- HLA is an architecture, not software
- *however, to facilitate cost-effective implementation of HLA, DMSO is developing an initial suite of HLA*

supporting software

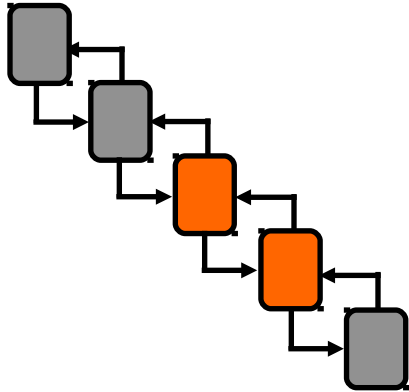


- DMSO facilitates open distribution of supporting tools in the public domain
 - Open access to specifications (e.g., OMT data interchange format) to foster development of commercial software to support HLA
 - Several DoD agencies have ongoing SBIR initiatives to develop HLA support tools
- Information source: HLA Online (subscribe at <http://hla.dmsso.mil>)
 - Open mailing list for HLA updates and HLA supporting software



HLA Supporting Software:

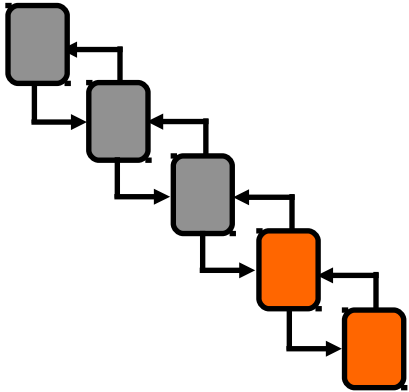
Conceptual Model Development and Federation Design



- **Object Model Library / Object Model Data Dictionary**
 - Web-Accessible repositories of reusable components
- **Object Model Development Tool**
 - Automated support for development of HLA Object Models
- **Federation Planners Workbook Tool**
 - Automates the population of FEPW Tables in the workbook
- **RID Editor**
 - Allows optimization of RTI initialization data



HLA Supporting Software: Federation Integration, Test and Execution



- **Federation Verification Tool**
 - Verifies that the federation meets the requirements specified in the FOM and FEPW
- **Federation Management Tool**
 - Provides runtime data on federation operations
- **Data Collection Tool**
 - Selectively records simulation data for manipulation and display on COTS software

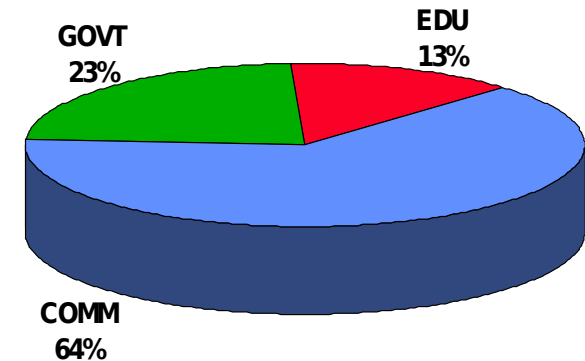
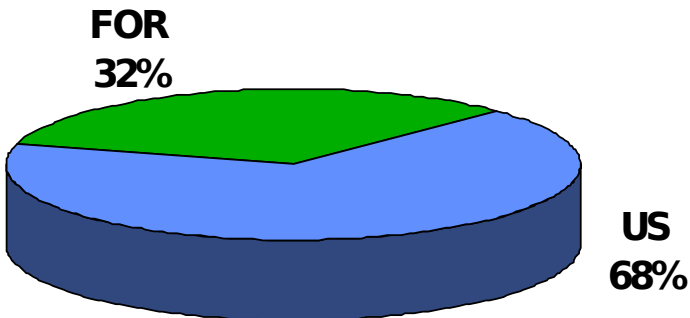
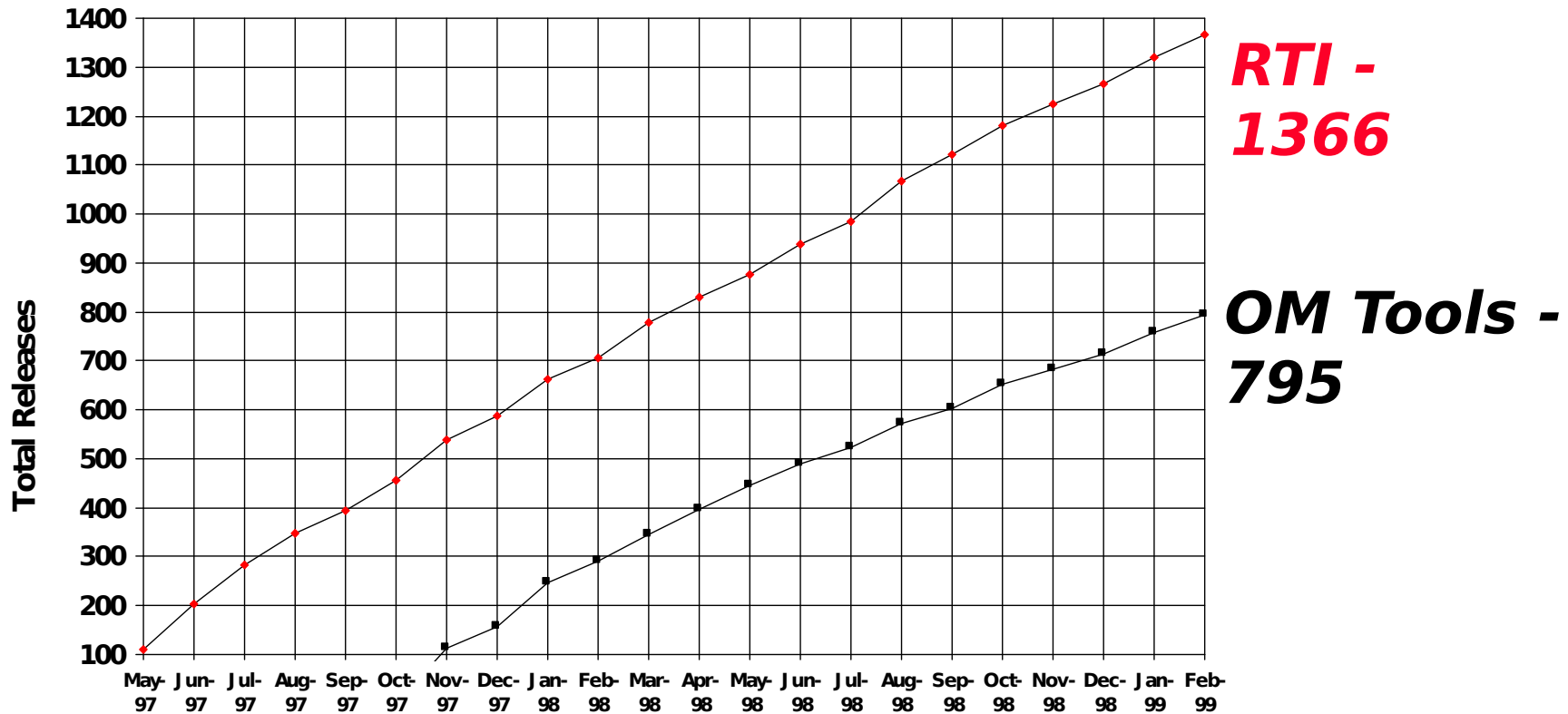


HLA Supporting Software: Runtime Infrastructure (RTI) Software

- RTI software is available now and can be ordered from the DMSO homepage (<http://hla.dmsso.mil>) under “Software Distribution Center”
- Each user defines own account name and password
 - User account approved following one-time submission of registration data
 - Once registered you will be automatically notified of new releases
- RTI version 1.3 is out now
 - Platforms supported in DMSO-sponsored development reflect broadest requirement among **current user** population; follow-on development among **commercial markets to address added demand**
- RTI version 1.3NG competitive development (under DMSO procurement) is underway; Beta release is out now
 - Will be released as RTI 1.3NG (Next Generation)



HLA Software Releases (through February 1999)





Top International HLA Software Requestors (through February 1999)

RTI

UK	69
GERMANY	63
FRANCE	50
CANADA	41
NETHERLANDS	
36	
SWEDEN, AUSTRALIA (tie)	27
JAPAN	24
SOUTH KOREA	
20	
SINGAPORE	18
SPAIN, TAIWAN (tie)	12
TURKEY	11

OM Tools

GERMANY	32
UK	30
FRANCE	24
AUSTRALIA	20
S KOREA	18
NETHERLANDS	17
SWEDEN, JAPAN (tie)	13
CANADA	12

ISRAEL - ITALY (tie)	8
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Cooperation with Commercial Tool Developers

- DMSO developments are intended to help create a market for commercial tools (not compete with commercial developments)
- Commercial developments are beginning both in the US and overseas
- Cooperative ventures initiated:
 - Commercial involvement in data interchange format (DIF) development
 - Bulletin board for commercial tools hosted on the HLA home page

HLA Tools Bulletin Board

Commercially Developed Tools

Government Sponsored Tools

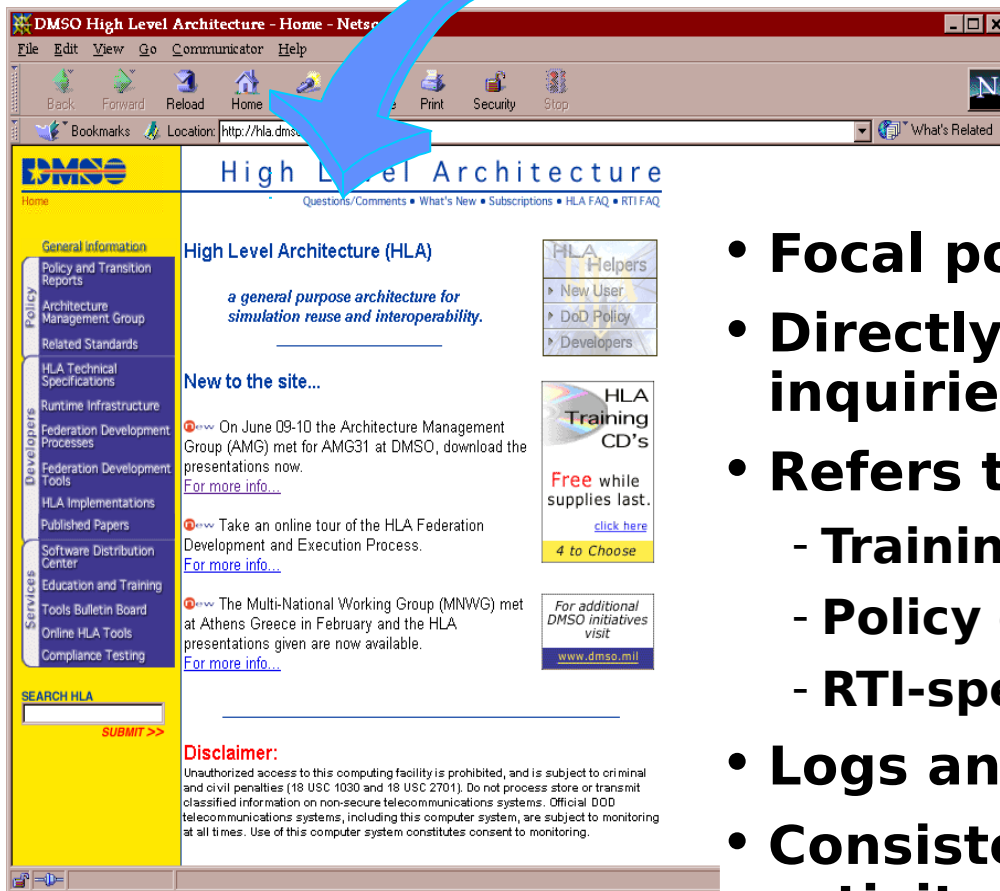
- A service to inform the community of tools and services available to support HLA implementations
- Products are listed alphabetically by company name
- Solicitation for product postings is made through the Bulletin Board
- Bulletin board is available through HLA Home Page to DoD, Academia and Industry

HLA User Services: HLA Help Desk



Integrated Training Program

- An on-line **Help Desk** was established in May 97
 - Can also access via Question and Comments Link on Home Page



- Focal point for inquiries on HLA
- Directly responds to general inquiries
- Refers to appropriate specialist:
 - Training requests
 - Policy questions
 - RTI-specific technical questions
- Logs and tracks all inquiries
- Consistently high level of activity

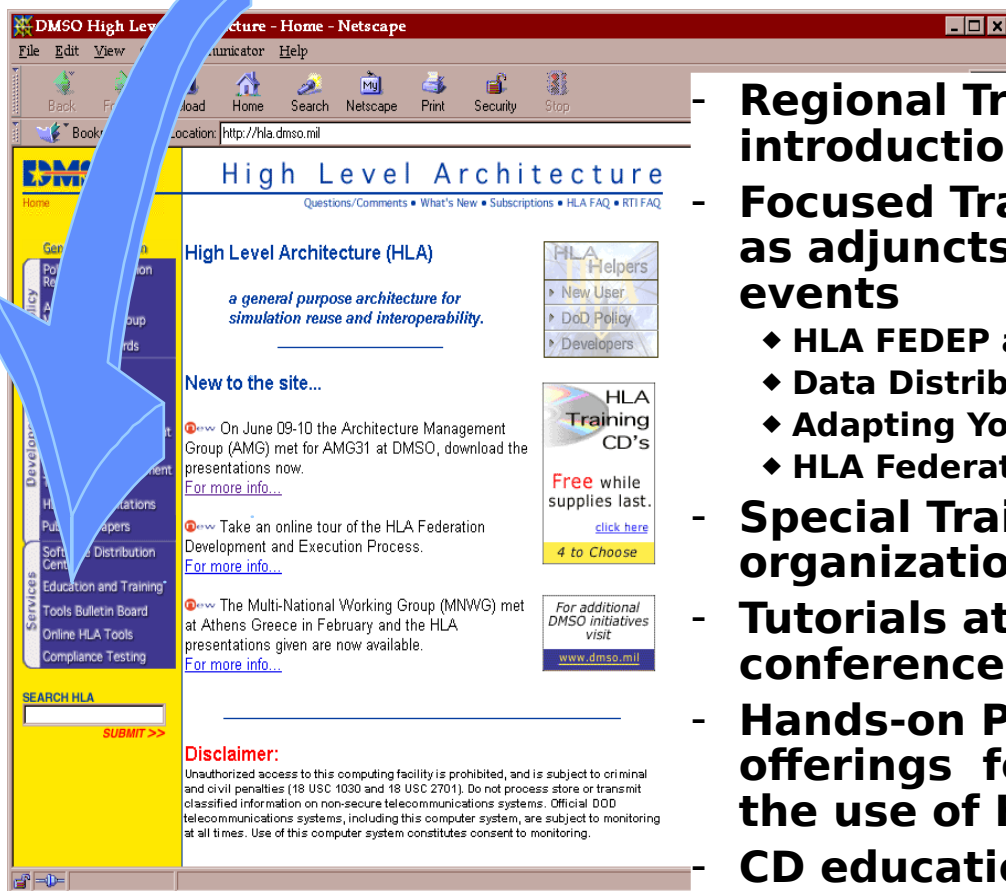
Access Through E-Mail to hla@msis.dmsso.mil

HLA User Services: HLA Education/Outreach



Integrated Training Program

- **Integrated DMSO HLA training/outreach program is under development**
 - ***No cost to recipients other than TDY costs***



- **Regional Training -- comprehensive introduction to HLA offered monthly**
- **Focused Training -- half day focused sessions as adjuncts to Regional/Special request events**
 - ◆ HLA FEDEP and Supporting Tools
 - ◆ Data Distribution Management in the HLA
 - ◆ Adapting Your Simulation to Use HLA
 - ◆ HLA Federate Compliance Testing
- **Special Training -- provided to a specific organization based on specific request**
- **Tutorials at simulation-related workshops, conferences, and symposia**
- **Hands-on Practicum -- twice a month offerings for implementer-level training in the use of HLA**
- **CD education materials supplement live training**
- **HLA Video**

Sign-up

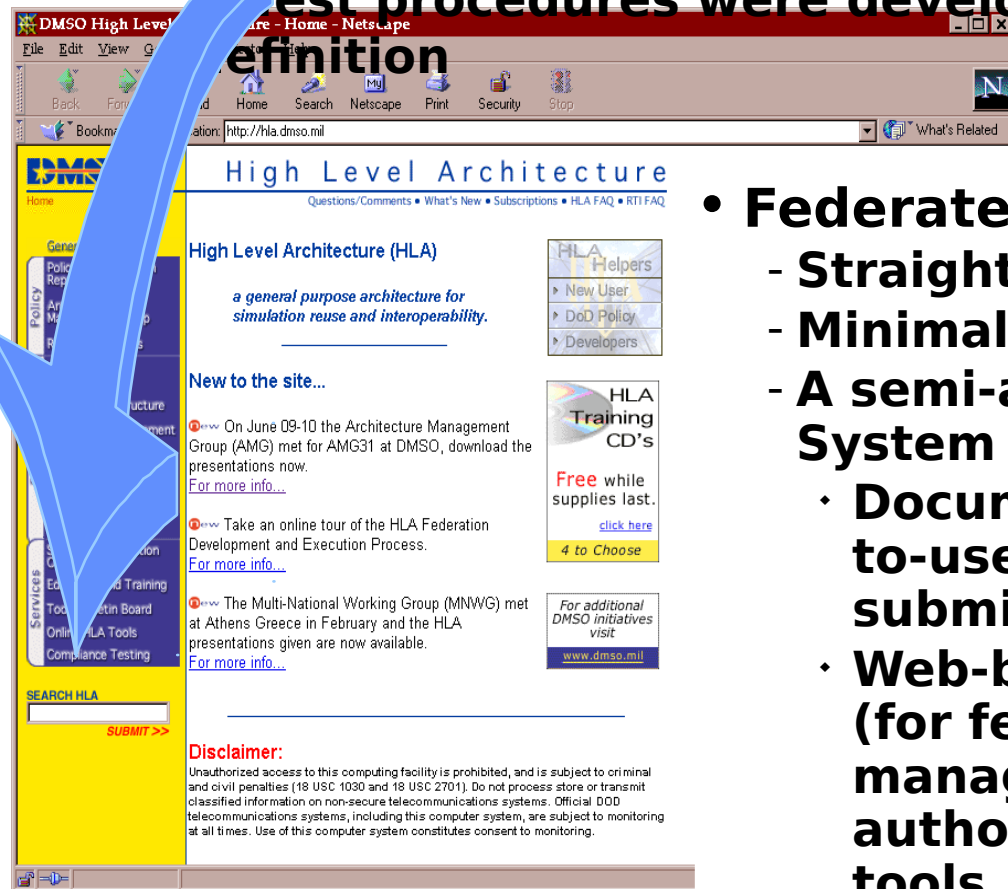
HLA User Services: HLA Federate Compliance Testing



Integrated Training Program

• Compliance to HLA defined in 'HLA Compliance Checklist'

Test procedures were developed with baseline definition



- **Federate compliance testing**
 - Straightforward, over the network
 - Minimal effort required by federate
 - A semi-automated Test Management System
 - Documented test process in easy-to-use guide: procedures, sizes, submission formats, examples, etc.
 - Web-based, on-line test preparation (for federates) and test management (for certification authority), integrated with test tools

- **RTI compliance testing system in**

HLA Standardization Initiatives



Integrated Training Program



• Government

- HLA established as technical architecture for DoD Simulations -- **Sept 96**
- HLA is a part of the DoD Joint Technical Architecture (JTA) -- **May 98**

• International

- HLA is named as NATO standard architecture in NATO M&S Master Plan prepared in June 98 and approved -- **Nov 98**

• Industry

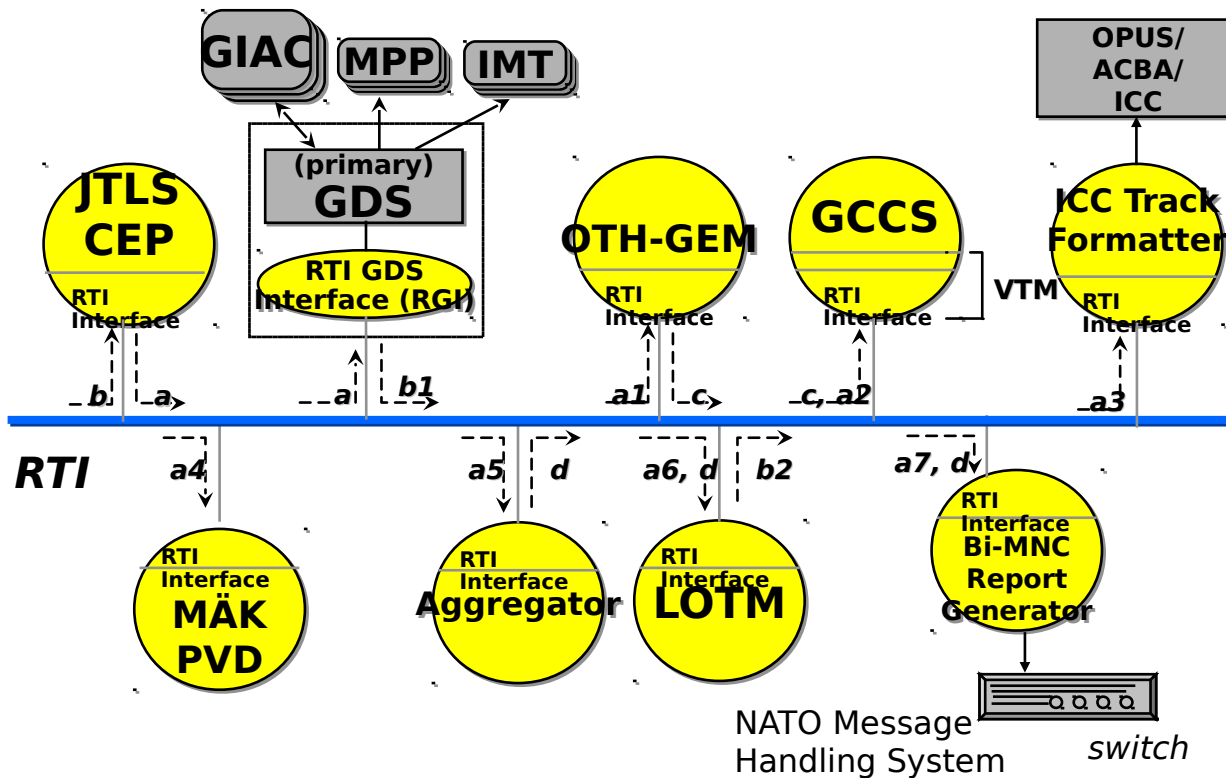
- Object Management Group (OMG) Standardization
 - HLA Interface Specification and RTI Services were approved as OMG standards -- **Nov 98**
- HLA is a draft IEEE standard, IEEE P1516

Back-Up Slides



JTLS-GCCS-NATO C2 Federation

- Use the HLA to build a Federation of a training simulation (JTLS) and combined (US and NATO) C2 applications



- Demonstrates several approaches for stimulating C2 systems with simulation data



JADS Partner Program

Objective:

To assess the utility of ADS (in this case, HLA) for EW by testing the effectiveness of a self-protection jammer in an ADS test environment, across three phases (OAR, DSM, ISTF)

Environment to be replicated



• Federates and Functions:

- Test Control (JADS JTF)
- 3 playback federates
 - Platform location, RF Environment, Terminal Threat Handoff
- DSM (GTRI) or ISTF (ACETEF)
- Threats (AFEWES)

• Products:

- RTI performance testing
- Process and Tool evaluations

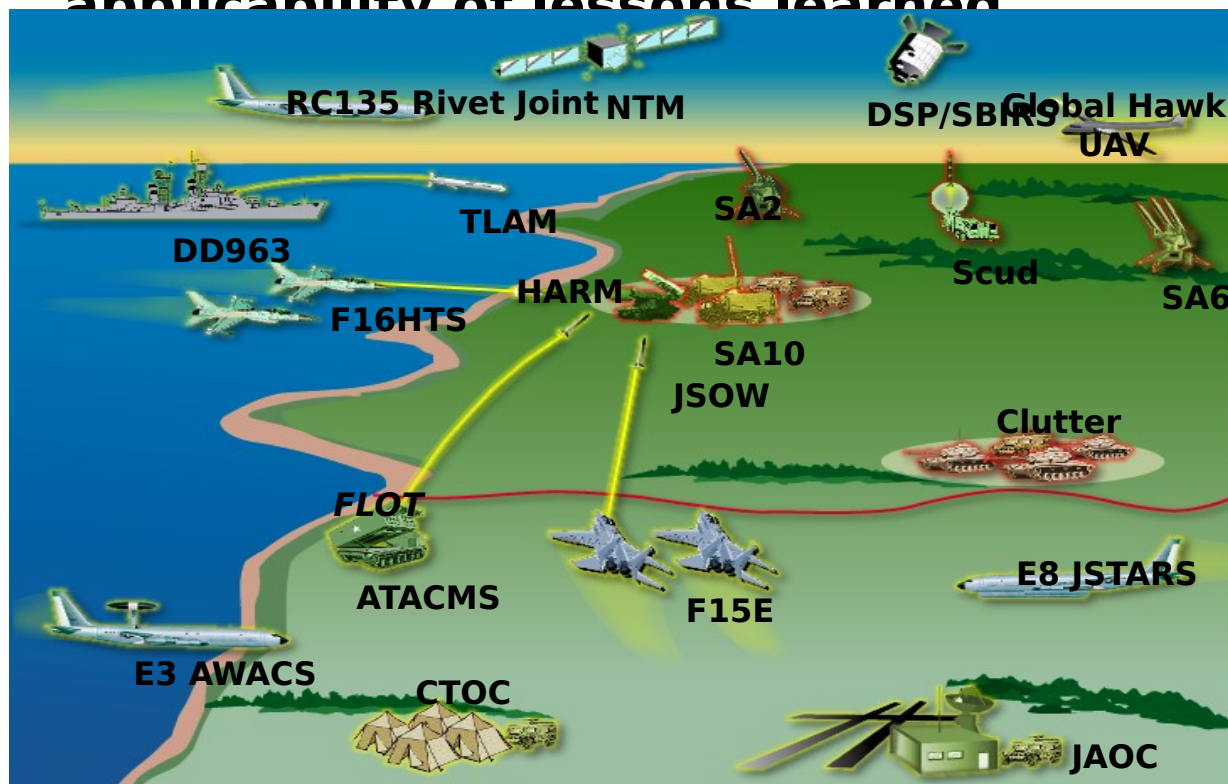
Correlation results



JWP Trailblazer Federation

Objectives:

- Practice the HLA Federation Development and Execution Process (FEDEP) in the domain of information superiority experimentation
- Be relevant and reasonable in domain to ensure applicability of lessons learned



EADSIM

- Red strategic SAMs
- Strike a/c
- JSTARS
- AWACS
- JAOC

NSS

- Aggregate

ELINT

- IR Launch Detection

Eagle

- Red ground